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THE PATENT OFFICE 0.00-0208599.1
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Your reference HOTDI Copy Detector (UK)

15 APR 2002

The Patent Office

Request for grant of a Patent

Form 1/77 Patents Act 1977

1 Title of invention

Method of detecting counterfeit documents

0208599.1

2. Applicant's details

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4 Reference Number

HOTDI Copy Detector (UK)

5 Claiming an earlier application date

An earlier filing date is claimed:

Yes ☐ No ☒

Number of earlier application or patent number

Filing date

15 (4) (Divisional)	8(3)	12(6)	37(4)
☐	☐	☐	☐

6 Declaration of priority

Country of filing	Priority Application Number	Filing Date

7 Inventorship

The applicant(s) are the sole inventors/joint inventors

Yes ☐ No ☒

8 Checklist

		Continuation sheets	0
Claims	1	Description	5
Abstract	0	Drawings	2

Priority Documents	~~Yes~~/No
Translations of Priority Documents	~~Yes~~/No
Patents Form 7/77	~~Yes~~/No
Patents Form 9/77	~~Yes~~/No
Patents Form 10/77	~~Yes~~/No

9 Request

We request the grant of a patent on the basis of this application

Signed: Origin Limited Date: 15 April 2002

(Origin Limited)

Method of Detecting Counterfeit Documents

Overview

Many anti-counterfeiting methods have been devised which involve the addition of security features such as holograms, specialised inks or printed patterns. These largely rely on the difficulty of reproducing the features at a sufficiently high standard. The printed patterns often involve features which are difficult to reproduce on standard printers.

This patent proposes a method, using existing printed patterns without adding any extra features, of detecting the type of degradation brought about by the scanning or printing processes and hence identifying copies.

Background to the Invention

Counterfeiting of currency and valuable documents is an activity which has attracted fraudsters throughout the ages and shows no signs of abating. Measures to protect currency are numerous and diverse. They include selecting particular physical attributes of paper, devising ink with unusual reflective properties, adding metallic strips and so on. They also include the printing of elaborate patterns that are difficult to reproduce without making apparent certain concealed designs. These are typically based on the moire phenomenon and the use of lines that are almost parallel.

The improvement in quality of cheap scanners and inkjet printers has conferred the ability to reproduce currency with a higher level of fidelity to the original. Visually some of this counterfeited material can be quite acceptable and could easily be passed off as genuine in ill lit environments, or in any context where there is little time or inclination to check for authenticity.

The achievable quality of reproduction is sometimes sufficient to defeat the embedded patterns in the sense that no very obvious artefacts emerge after printing. This type of counterfeiting deterrence also has the disadvantage that it requires individual inspection of notes and is not easily amenable to machine detection.

A more recent development has been in the field of digital watermarking where a signal is added at a barely perceptible level but is able to be detected by scanning and carrying out a statistical accumulation. of data. This method generally involves the embedding of an amount of digital data.

A weakness of the watermarking method is that in most cases watermarks require the geometric attributes of the image to be largely preserved. Attacks on watermarks often feature minor distortions in order to benefit from this weakness. This is true even of watermarks generated using wavelets or in the frequency domain. This means that documents that are damaged by tearing or crumpling will tend to lose their watermarks.

The present invention relies on the measurement of "intensive" variables, variables that are not primarily dependent on the extent or shape of an image. This contrasts with "extensive" variables which depend on the extent or shape of an image and would thus be corrupted by stretching or the like.

Summary of the Invention

The present invention does not add any particular security pattern. Rather it relies on the fact that virtually all currency and many valuable documents use patterns of fine lines as part of their designs. These lines are typically printed in spot colours and not in the mixture of graded tones that are used to convey images.

The essence of the invention is the recognition that even the highest quality printer necessarily introduces a degree of diffusion and randomness into the original electronic pattern. Part of the randomness stems from the unpredictable flow of ink on paper, an unpredictability which is more pronounced on the types of fibrous paper used in currency.

Equally even the highest quality of scanner will introduce inaccuracies by virtue of the fact that the receptors on the scanner can never be precisely lined up with the edges of features on a printed document.

The invention describes a method whereby the effects of diffusion and scanning can be measured and a threshold developed that will separate the copied file from the original.

The general implementation of the invention requires the use of some standard line pattern as part of currency design. The actual nature of the pattern is of no import except insofar as it consists of lines having reasonably sharp edges. Samples of the currency are scanned to a file.

In a first implementation a simple differencing filter is then applied to produce a transformed image. A histogram of values is constructed from the image. An important feature of the histogram is a "shoulder" or a valley resulting from a characteristic jump in the difference values.

When the document is scanned and then reprinted using an ink jet printer the sharp line edges suffer a further diffusion. The histogram of the differences can again be constructed and the valley will be found to have disappeared.

An important property of this method is that deforming of the document does not affect the histogram in a major way because the histogram is based on the aggregation of local values rather than a relation between values at known displacements from one another.

In a second implementation the fragmentation of lines is measured making use of the fact that after scanning and printing lines cease to retain the smooth structure that appears on the screen when viewing electronic files.

Detailed Description

The descriptions that follow will be related to currency designs but are equally applicable to any security documents which make use of line patterns. Passports, driving licences etc fall within this category.

There are certain standard patterns which currency printers tend to generate for their designs because they provide a suitable background matrix and, by their fine structure, are difficult to copy. This invention requires that such a line pattern be present in the currency under consideration. Preferably the lines will be at a frequency of at least 50 per inch and there must be clear space between the lines. Such lines are present, for instance, on a UK ten pound note.

Samples of the currency are scanned at a selected resolution on the range of scanners which is most appropriate for detection purposes. In implementations designed for detection at numerous distributed sites these scanners may be simple flatbed scanners. The quality of scan tends to lie within quite narrow limits but it is a simple matter to provide calibration samples and software.

In further implementations web cameras or digital cameras may be used for the image capture; there will in most cases a need to define the parameters under which they operate to give the repeatability that arises from the use of scanners.

The first method according to this invention for detecting counterfeits measures the diffusion effect on line edges. The scanned data values will include many transitions from high values to low values in whatever colour space or luminance space is being used, corresponding to the change of visual effect between the peak of the lines and the intervening valleys. A differencing filter can be applied to collect data describing the jump from any pixel to its neighbour,
From this derivative image a histogram can be created. Figs 1a and 2a, illustrate a typical histogram for each of two common line patterns..

The histogram has a peak and a valley arising from the fact that there are certain characteristic jumps which occur when lines are printed at high quality in a single colour. These features and the general shape of the curve can be expressed in mathematical terms. One simple expression is illustrated by the derivative curve which has zeros.

This histogram is to be compared with that obtained after attempts to copy the currency using a scanner and an inkjet printer. A typical histogram of this type is illustrated in figures 1b and 2b. The peak and valley have been eliminated and there are no zeros in the derivative curve..

The reason for the change of histogram is that the inkjet printer will add a further diffuseness to the line pattern, thus producing derivative values in a more or less continuous distribution. The histogram will therefore have no peaks or valleys corresponding to preferred or unlikely values.

One reason for diffuseness on ink jet printers is the fact that they generally print in three or more colours and will attempt to simulate the spot colour on the currency by the use of three or more dots of different colours. The derivative image produced from the scan will correspond to changes in luminance which will in turn be composed of contributions from several colours resulting in a general spread of values.

The histograms will vary according to all of the parameters involved in the printing and scanning process. These parameters include paper quality, print resolution, colour chosen for the pattern, frequency of the line pattern and so on. It is nonetheless possible to produce characteristic values for the histograms that will allow a threshold between originals and copies to be identified for a wide range of contexts, thereby providing an automatic method of counterfeit identification.

The second method according to this invention for detecting counterfeits measures the fragmentation and edge deformation arising from the copying process.

If a straight line in an electronic file is printed the straight edge will undergo a degree of deformation, more especially if the substrate is fibrous paper where the ink flow cannot be precisely predicted. If this printed version, which could be, for example, a cheque or an item of currency, is scanned the scanner cannot be precisely aligned with the pixels of the original pattern. Thus, in addition to the inevitable noise introduced by the scanning hardware there is a kind of sampling error. This is more apparent if the scan is in black and white rather than contone or if the scan, originally in contone, is thresholded.

The main result of this is that after lines have been copied and scanned to a black and white image the lines will be more fragmented and irregular. The objective in this invention is to provide metrics that will reflect the degree of fragmentation.

One metric is obtained by considering for each black pixel the number of black neighbours. Thus points on the edge of a straight line would have 5 black neighbours, as illustrated by the pixel marked 'P' below.

WWWWWWWWWWWWWWW
BBBBBBBBPBBBBBBBBB
BBBBBBBBBBBBBBBBBB
BBBBBBBBBBBBBBBBBB
WWWWWWWWWWWWWWW

After copying the line might become more irregular as illustrated below.

In this case P has only 4 black neighbours.

WWWBWWWWBWWWW
BBBBBBWWPBBWBBBBBB
BBBBBBBBBBBBBBBBBBB
BBBBBBBBBBBBBBBBBBB
WWWWWWWWWWWWWW

Thus a simple method of describing the fragmentation would be by a histogram of the numbers of neighbours for each point. In relatively low grade copying this is sufficient to distinguish a copy from and original.

To develop the invention further a means of classifying pixels is devised as in figure 3b. Each of the surrounding pixels is given a value so that the sum of the values gives a unique description of the configuration. Figure 3a shows the result of analysing an image using this metric. The profile obtained compared with that of a copy of the same document will show clear distinction.

A further refinement is to identify certain configurations as 'good,' i.e. more common in smooth originals, and certain configurations as 'bad' and forming an index from the ratio of the two. The value of the index can be taken as a measure of the likelihood of counterfeiting.

A further part of the invention is the embedding of information about the profiles into the document in an encoded form to make detection of copies self contained.

Another development is to include a known less obvious pattern within the line pattern so that anyone wishing to counterfeit documents is obliged to copy rather than generate new documents .

Claims

1. Detection of copies without modifying existing designs by detecting the type of degradation brought about by the scanning or printing processes
2. The above detection process coupled with the use of a derivative image and histogram
3. Detection of copies without modifying existing designs by use of line fragmentation measures.
4. The above processes plus use of particular patterns
5. The above processes plus use of web/digital camera
5. The above processes taking into account characterisation of inkjet (and other) printing process.

Fig. 1a

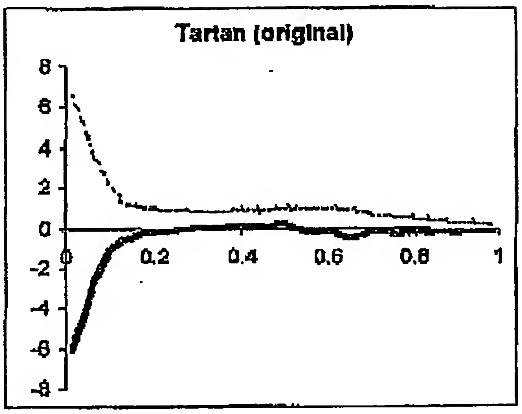

Fig. 1b

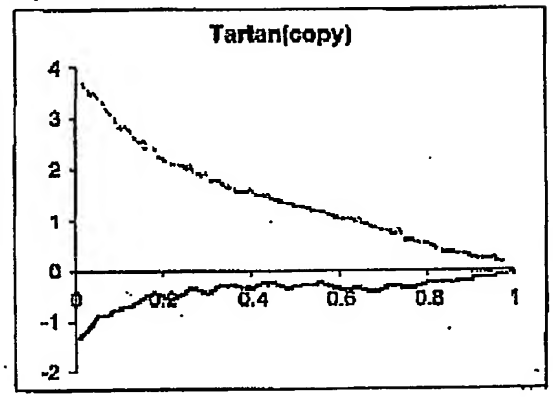

Fig 1:The normalised Histogram Of The Derivative Image (HOTDI) (dotted line) and its first derivative (thick solid line) for a tartan pattern :(a) original, (b) copy.
Note that there is a valley near 0.33 in the HOTDI of the original, but no such feature exists in the histogram of the copy.

Fig. 2a

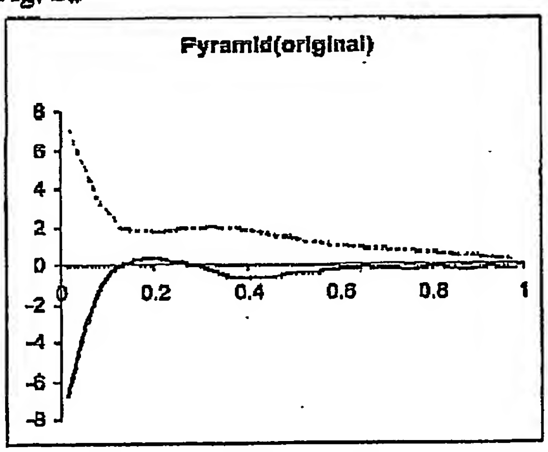

Fig. 2b

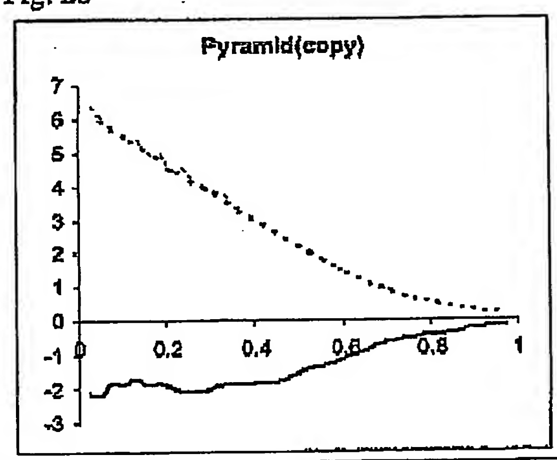

Fig 2: The normalised Histogram Of The Derivative Image (HOTDI) (dotted line) and its first derivative (thick solid line) for a pyramid pattern :(a) original, (b) copy.

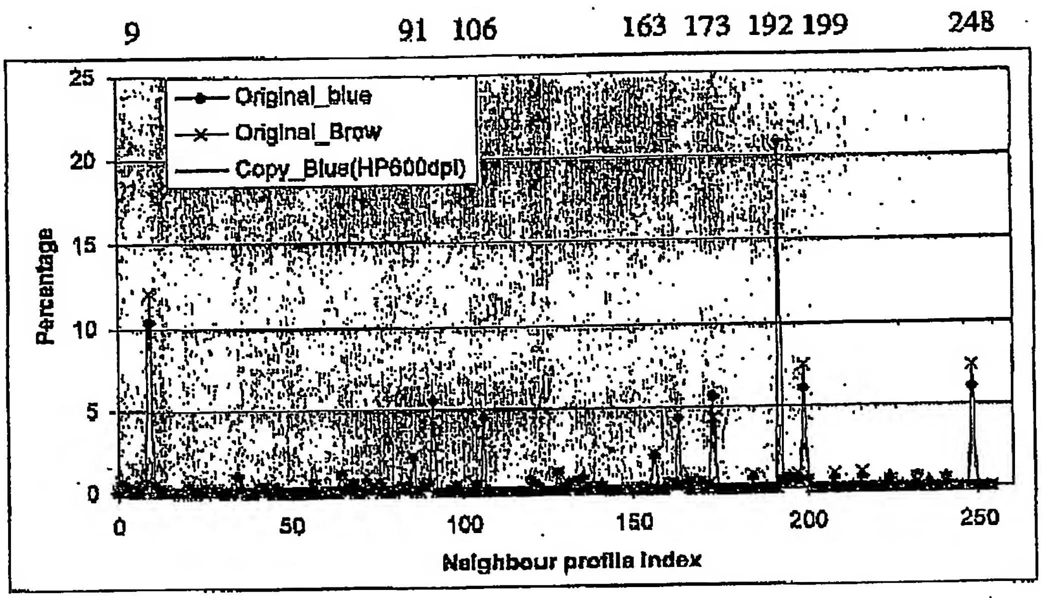

Fig. 3a Results of neighbouring profile analysis (black pixel with black neighbours) for two original printings and a copy of the Tartan pattern.

Fig 3b Matrix used for neighbouring profile index:

4	128	32
1		8
2	64	16

(In the centre is the sample pixel.)

Fig 3c The neighbouring profiles corresponding to the 8 main peaks in Fig. 1 are (B and W represent black and white respectively):

W W W	W B W	B B W	B B B
B B B	W B W	B B W	B B B
W W W	W B W	B B W	W W W
Index=9	index=192	index=199	index=173
W B B	W W W	W W B	W B B
W B B	B B B	W B B	B B W
W B B	B B B	B B W	B W W
Index=248	index=91	index=106	index=163